Equivalent Dihedral Angle

Some multi-panel wings have *polyhedral*, which is a spanwise-varying dihedral angle $\Upsilon(y)$. In order to apply stability and control criteria to such a wing, it is necessary to determine its *Equivalent Dihedral Angle*, or EDA, in terms of $\Upsilon(y)$. This EDA then takes the place of the constant Υ which appears in stability and control criteria.

Using the convenient normalized spanwise coordinate $\eta \equiv 2y/b$, the EDA is computed as a weighted average of $\Upsilon(\eta)$. Assuming the spanwise loading is approximately elliptical, the appropriate weight function is the ellipse $(1 - \eta^2)^{1/2}$ times the roll moment arm η .

$$EDA = \frac{\int_0^1 \Upsilon \ (1-\eta^2)^{1/2} \eta \ d\eta}{\int_0^1 (1-\eta^2)^{1/2} \eta \ d\eta} = 3 \int_0^1 \Upsilon \ \left(1-\eta^2\right)^{1/2} \eta \ d\eta \tag{1}$$

This is still gives good results for more general wings with non-elliptical loading. It's useful to note that $EDA = \Upsilon$ for the case of a simple V-dihedral wing with constant $\Upsilon(\eta)$.

By introducing the cubed-ellipse function

$$f = (1 - \eta^2)^{3/2}$$
 (2)

$$df = -3 \left(1 - \eta^2 \right)^{1/2} \eta \, d\eta \tag{3}$$

equation (1) can be rewritten as follows.

$$EDA = \int_{1}^{0} \Upsilon \, df \tag{4}$$

For the usual case where the wing consists of flat panels, Υ is piecewise constant, with values $\Upsilon_1, \Upsilon_2...$ in between the dihedral-break stations $\eta_0, \eta_1, \eta_2...$ The integral (4) can then be written as a sum over the individual panels. The 2-panel case is shown in Figure 1.

$$EDA = \Upsilon_1 (f_0 - f_1) + \Upsilon_2 (f_1 - f_2) + \dots$$
 (5)

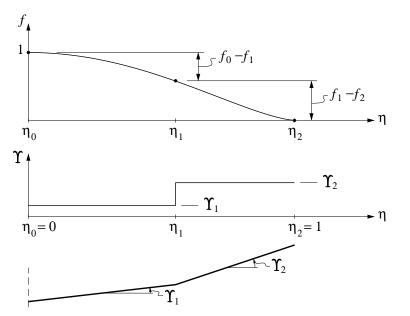


Figure 1: Quantities used for calculating the EDA of a 2-panel polyhedral wing.